

and without significant damage to overlying skin layers. More particularly, the invention relates to the treatment of psoriasis by destroying the blood vessels underlying psoriatic plaque.

As may be best seen in Fig. 2 of the application, the absorption of radiation by hemoglobin/blood drops off very sharply at a wavelength of approximately 600 nm. Therefore, the conventional wisdom in the past was that, in order to destroy blood vessels, one must use laser energy at a wavelength of less than 600 nm. This prior art thinking is reflected in Itzkan which seeks to destroy blood vessels by operating in "the entire range of visible wavelengths shorter than approximately 600 nm" (column 2, lines 8 and 9).

Further, while attempts have been made to treat psoriasis with lasers operating in this wavelength, such treatment has been only marginally successful (refer for example to the article by J.E. Rasmussen which is cited by the Applicants in their Information Disclosure Statement). One reason why such treatments for psoriasis have not been more successful can be seen from Fig. 3b which illustrates the penetration depth at a wavelength of 577 nm, which is a preferred wavelength for such treatment. Assuming blood vessel damage occurs at a temperature greater than 60°C, it is seen that blood vessel destruction will occur only to depths of approximately .5 mm. There is strong evidence to the effect that destruction of

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blood vessels at a much greater depth, for example depths up to 1 mm, is required for successful treatment of psoriasis and may also be desirable for treatment of other dermatological conditions.

However, transmission of light through human skin is largely determined by absorption of various chromophores within the tissue (e.g., hemoglobin, melanin, water). As can be seen from Fig. 2, the absorption of these various chromophores varies widely over the wavelengths of interest. Because water is by far the single largest component of human tissue, a wavelength in the 300 nm to 1000 nm range would appear desirable since water absorption is very low in this range. However, at wavelengths shorter than about 700 nm, the absorption of light by melanin (the brown pigment in the skin) and by hemoglobin causes much of the incident light to be absorbed within a few hundred microns of the skin surface (see Fig. 3b). If the energy is increased to get sufficient energy to the deep vessels at wavelengths shorter than about 700 nm, explosion of surface vessels (for pulse light) or burning of the skin (with continuous energy sources) can occur.

This poses a dilemma for destruction of blood vessels at deeper levels since the energy which blood optimally absorbs to cause destruction of vessels is in a wavelength range at which deep penetration does not occur, while for the wavelengths at which deep penetration occurs, blood does not absorb well and

the conventional thinking was that destruction of blood vessels could not be achieved. This is evident from both the Itzkan reference which performs destruction of blood vessels at wavelengths below 600 nm, and Tan which operates at the higher wavelengths where deep penetration can occur, but utilizes these wavelengths because the pigments or dyes which she is seeking to destroy absorb at these wavelengths and in no way suggests that her device could be utilized to destroy blood vessels at any depth, far less at deep depths.

However, the Applicants have realized that in spite of the very low absorption by blood at the infrared wavelengths in the 700-1100 nm range, by careful modeling, there is sufficient laser energy taken up by the blood vessels under certain circumstances to achieve selective damage. This result occurs because the absorption of other chromophores in the bulk tissue is approximately 30 times less than that of blood at these wavelengths. Thus, while blood absorption is very low, it still absorbs a majority of the deposited energy. This unexpected result permits selective destruction of deep microvessels. However, in order to achieve destruction of deep microvessels without causing bursting of surface microvessels, it is important that the total fluence be provided over a longer time interval. In particular, the destruction of microvessels at depths of up to 1 millimeter can be achieved without adverse surface layer effects when the fluence between

5 joules per square centimeter and 50 joules per square centimeter is provided in pulses having a duration between 0.2 milliseconds and 20 milliseconds. This is contrary to the teaching in Tan where fluences in a lower but overlapping range are delivered in pulses having a duration in a range of about 10-300 nanoseconds (column 8, lines 43-45), a range which is a small fraction of the range of the current application. Therefore, Tan neither shows nor suggests in any way the destruction of blood vessels by use of laser energy in the infrared (700-1100 nm) range and, in particular in no way suggests that operation in this wavelength range with pulses several orders of magnitude longer than Tan will result in destruction of blood vessels at a depth of up to approximately 1 millimeter. Therefore, both Itzkan and Tan represent the prior art which indicated that what the Applicants have disclosed and claimed could not be achieved and these references, neither alone nor in combination, in any way show or suggests the Applicants' invention as disclosed and claimed.

The two independent claims remaining in this application clearly reflect the Applicants' invention. In particular, both of these claims require operation outside of the wavelength range taught by Itzkan and for time intervals substantially longer than those taught by Tan. As is discussed above, there is nothing in either reference which suggest that operating at the wavelengths in the 700-1100 nm range with pulses of the

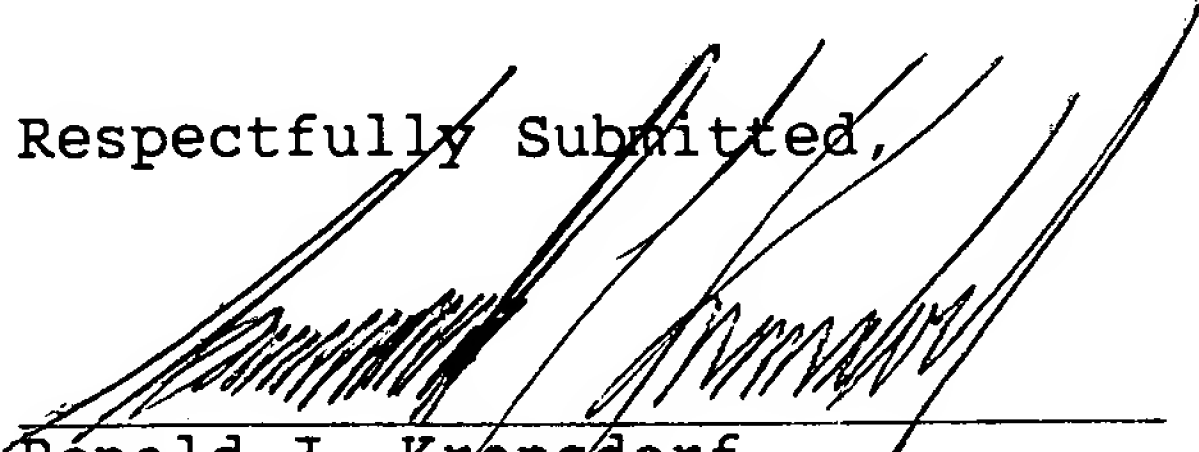
indicated fluence and pulse width would in fact result in the deep destruction of blood vessels in general and in the destruction of such blood vessels for the treatment of psoriasis in particular, and the conventional thinking at the time the invention was made was in fact that this was not the case.

In view of the above, it is respectfully submitted that the claims now in this application are novel, unobvious and patentable. Allowance of these claims is respectfully requested.

I hereby certify that this correspondence is deposited with the United States Postal Service as first class mail in an envelope addressed to: Commissioner of Patents and Trademarks, Washington, D.C. 20231, on August 17, 1994

DATE

Respectfully Submitted,


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